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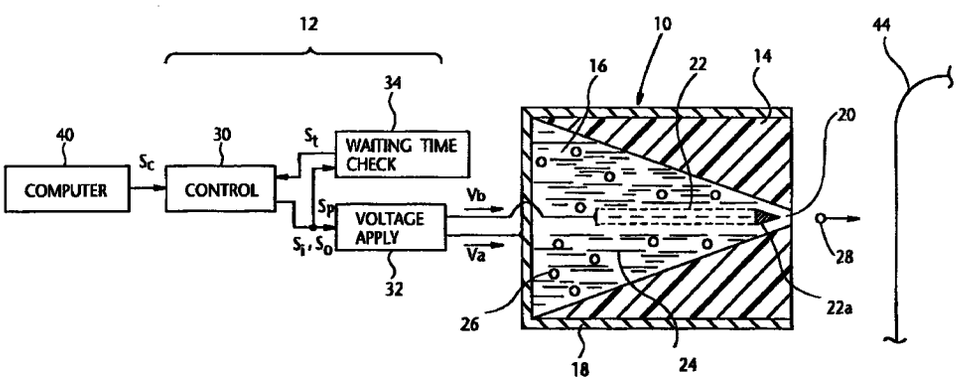
(54) Ink-jet printer to use ink containing pigment particles

(57) The invention relates to an ink-jet printer which uses an ink containing fine solid particles of a pigment suspended in a carrier liquid. The print head of the printer has an ink ejection orifice at one end of an ink chamber, and the ink chamber is provided with a first electrode to which a first DC voltage is applied for concentrating the pigment particles in the vicinity of the orifice by electrophoresis and a second electrode to which a second DC voltage in pulse form is applied for ejecting an agglomeration of the pigment particles together with a small amount of carrier liquid from the orifice. In the printer the length of waiting time, which elapses from the decay of a pulse of the second voltage, is checked. When the waiting time is relatively long, the polarity of the first voltage is inverted to prevent excessive concentration of pigment particles in or in the vicinity of the orifice, and/or the second voltage is modified to promote movement of pigment particles in the vicinity of the second electrode toward the tip of the second electrode.

FIG. 1



EP 0 761 441 A2

Description

This invention relates to an ink-jet printer which uses an ink containing fine solid particles of a pigment suspended in a carrier liquid. More particularly, the ink-jet printer is of the type utilizing electrophoresis of the pigment particles in the ink in an ink chamber of the print head for concentrating the particles in the vicinity of an ink ejection orifice provided at an end of the ink chamber.

In known ink-jet printers of the above-mentioned type, the ink chamber in the print head is provided with a first electrode to which a steady DC voltage is applied to produce an electric field in the ink chamber thereby to induce electrophoresis of the electrically charged pigment particles in the ink toward the ink ejection orifice. As the pigment particles migrate toward the orifice at a definite rate, the particles concentrate in the vicinity of the orifice. A second electrode is disposed in the ink chamber close to the orifice. After concentrating the pigment particles in the vicinity of the orifice, a DC voltage in pulse form is applied to the second electrode to cause ejection of an agglomeration of the pigment particles together with a small amount of the carrier liquid from the orifice toward a recording surface. On the recording surface the agglomeration of pigment particles forms a single dot. By repeating this process while the ink chamber is replenished with the ink, an image is printed on the recording surface. When the pulse duration of the voltage pulse is relatively long, each pulse causes ejection of a few or several agglomerations of pigment particles one after another at nearly constant time intervals, and on the recording surface these agglomerations form a single dot of a relatively large size.

In the operation of the ink-jet printer described above, concentration of the pigment particles in the vicinity of the ink ejection orifice reaches an excessive extent if the application of a voltage pulse to the second electrode is interrupted for a relatively long period of time. Then, it is likely that the orifice is clogged with the pigment particles. Even though the orifice is not clogged, the ejection of an agglomeration of pigment particles will become unstable. These phenomena lead to degradation of the printing quality.

When the time interval between two pulses of the voltage applied to the second electrode is relatively long, there arises another problem that the ejection of an agglomeration of pigment particles by the later pulse is liable to be delayed or missed. This is because the pigment particles tend to move away from the tip part of the second electrode before the application of the later pulse of voltage to the second electrode.

It is an object of the present invention to provide an improved ink-jet printer of the above-described type to solve the problems explained above.

An ink-jet printer according to the invention uses an ink containing fine solid particles of a coloring material suspended in a carrier liquid, and the printer comprises a print head comprising (i) an ink chamber to be filled with the ink, (ii) an ink ejection orifice located at one end of the ink chamber, (iii) a first electrode provided to the ink chamber to produce an electric field in the ink chamber such that by electrophoresis induced by the electric field the particles in the ink in the ink chamber are concentrated in the vicinity of the orifice and (iv) a second electrode which is disposed in the ink chamber and has a tip part positioned close to the orifice to produce another electric field to eject at least one agglomeration of the particles of coloring material together with a relatively small amount of the carrier liquid from the orifice, and a control part which comprises first means for applying a first DC voltage to the first electrode and periodically applying a second DC voltage in the form of pulse to the second electrode based on externally supplied print information, second means for checking the length of waiting time elapsed from the decay of a pulse of the second DC voltage and third means for modifying at least one of the first DC voltage and the second DC voltage when the waiting time is relatively long.

To prevent excessive or unwanted concentration of the particles of the coloring material (pigment particles) in the vicinity of the ink ejection orifice, the first DC voltage applied to the first electrode is modified so as to prevent or suppress the migration of the particles toward the orifice when the checked waiting time is not shorter than a first predetermined length of time. In a preferred embodiment of the invention, the polarity of the first DC voltage is inverted to cause the pigment particles to migrate in the direction opposite to the orifice. The inverted polarity of the first DC voltage is returned to the original polarity if the application of a next pulse of the second DC voltage to the second electrode is demanded before the lapse of a second predetermined length of time from the inversion of the polarity. Otherwise, the application of the first DC voltage to the first electrode may be interrupted after the lapse of the second predetermined length of time so that the print head can assume a stand-by state without unwanted concentration of pigment particles in the vicinity of the orifice.

For the purpose of concentrating the pigment particles on the tip part of the second electrode in preparation for the ejection of an agglomeration of pigment particles from the orifice, the second DC voltage is modified when waiting time between a pulse of the second DC voltage and a next pulse is not shorter than a predetermined length of time. A preferred manner of modifying the second DC voltage is applying a pilot DC voltage to the second electrode just before applying the next pulse of the second DC voltage to the same electrode. The pilot voltage is a voltage that is effective for moving the pigment particles exisiting in the vicinity of the orifice toward the tip of the second electrode but is ineffective for ejecting the particles from the orifice. An example of the pilot voltage is a pulse train consisting of a few or several rectangular pulses each of which is shorter in pulse duration than each pulse of the second DC voltage. Another manner of modifying the second DC voltage is augmenting the amplitude of the above-

mentioned next pulse of the second DC voltage.

With an ink-jet printer according to the invention, stable and quick ejection of an agglomeration of pigment particles can be accomplished by each pulse of the second DC voltage applied to the second electrode even though a relatively long period of time has elapsed from the application of the preceding pulse of the second voltage.

Fig. 1 is a schematic illustration of the principal parts of an ink-jet printer embodying the invention;
Fig. 2 is a chart showing the fundamental operation of the printer of Fig. 1;
Figs. 3 and 4 are flow charts of a program for varying a voltage applied to a first electrode in the print head of the printer of Fig. 1;
Figs. 5 and 6 are charts showing variations in the above-mentioned voltage in two different cases, respectively;
Fig. 7 is a schematic illustration of the principal parts of an ink-jet printer which is another embodiment of the invention;
Fig. 8 shows a meniscus of ink developed at an ink ejection orifice of the printer of Fig. 7;
Fig. 9 shows retrogradation of the ink meniscus of Fig. 8; and
Fig. 10 is a chart showing a temporary modification of a voltage applied to a second electrode in the print head of the printer of Fig. 7.

Fig. 1 shows the principal parts of an ink-jet printer as an embodiment of the invention. The printer has a print head 10 and a control part 12 which includes a control circuit 30, a voltage applying circuit 32 and a waiting time checking circuit 34. In practice, the print head 10 has a plurality of ink ejection orifices. However, for simplicity, Fig. 1 shows only one ink ejection orifice 20.

In the print head 10, an ink chamber 16 for the ink ejection orifice 20 is formed in a dielectric body 14 such as a synthetic resin body. The ink chamber 16 has a conical shape, and the orifice 20 is at the apex of the conical chamber 16. That is, the cross-sectional area of the ink chamber 16 gradually decreases toward the orifice 20. To produce an electric field in the ink chamber 16, an electrode 18 in the shape of a hollow cylinder closed at one end is fitted around the body 14 such that the closed end of the electrode 18 is located at the base end of the conical ink chamber 16. The electrode 18 and the body 14 have the same length so that the orifice 20 is in the center of the open end of the electrode 18. In the ink chamber 16 there is another electrode 22 having a tip part 22a which is the principal part of the electrode 22 and is positioned close to the orifice 20 and pointed toward the orifice 20. It is optional to modify the arrangement of the electrode 22 such that the tip of this electrode slightly protrudes from the orifice 20.

The ink chamber 16 is filled with an ink 24, which contains fine solid particles 26 of a pigment (coloring material) suspended in a carrier liquid. The pigment particles 26 in the ink 24 are inherently electrically charged. When an appropriate electric field exists in the ink chamber 16, the electric field causes electrophoresis of the particles 26 such that the particles 26 migrate toward the orifice 20 and concentrate in the vicinity of the orifice 20. For this purpose, a DC voltage V_a (will be called electrophoresis voltage) is applied from the voltage applying circuit 32 to the electrode 18. When an appropriate DC voltage V_b (will be called ejection voltage) is applied to the electrode 22 after concentrating the pigment particles 26 in the vicinity of the orifice 20, at least one agglomeration 28 of pigment particles 26 together with a small amount of the carrier liquid is ejected from the orifice 20 toward a recording material 44 such as a paper sheet.

The control circuit 30 of the printer supplies a printing signal S_p to the voltage applying circuit 32 based on print information S_c supplied from a print demanding electronic device 40 such as a personal computer. The print information S_c contains print data and print control signals. The control circuit 30 includes an input-output interface, CPU, ROM and RAM and controls the operation of the voltage applying circuit 32 according to a stored program. The function of the waiting time checking circuit 34 will be described later.

Referring to Fig. 2, the fundamental operation of the printer of Fig. 1 is as follows. As the electrophoresis voltage V_a, a constant DC voltage V_1 is applied to the electrode 18 to produce an electric field in the ink chamber 16. In the electric field the charged particles 26 of the pigment in the ink 24 migrate at a definite speed toward the ink ejection orifice 20, and after a short period of time the particles 26 concentrate in the vicinity of the orifice 20. Then, as the ejection voltage V_b, a DC voltage V_2 in the form of a rectangular pulse is applied to the ejection electrode 22 to produce an electric field which acts in the direction of the recording material 44 in the vicinity of the orifice 20. In this case the pulse duration t_2 of the voltage V_2 (V_b) is relatively short. By the action of the Coulomb force attributed to this electric field, an agglomeration 28 of pigment particles 26 concentrated in the vicinity of the orifice 20, together with a small amount of the carrier liquid, is ejected from the orifice 20 toward the recording material 44. The ejected agglomeration 28 of particles 26 impinges on the recording material 44 to form a dot. After the ejection of the agglomeration 28 of pigment particles the ink chamber 16 is replenished with the ink 24, and after the lapse of a period of time t_1 another pulse of voltage V_2 is applied to the electrode 22 to eject another agglomeration 28 of particles 26. By repeating this process an image is printed on the recording material 44.

When the pulse duration of the ejection voltage V_b (V_2) is considerably longer than t_2 in Fig. 2, a few or several agglomerations 28 of pigment particles are ejected one after another at nearly constant time intervals which are nearly equal to t_2 in Fig. 2, and on the recording material 44 these agglomerations 28 form a single dot

of a relatively large size.

The waiting time checking circuit 34 always checks the length of time elapsed from the decay of each pulse of the ejection voltage V_b and supplies a signal S_t representing the length of the elapsed time to the control circuit 30. For this purpose the time checking circuit 34 receives information about the ejection voltage V_b contained in the printing signal S_p.

When the length of tide represented by the signal S_t is not shorter than a predetermined length of time T_1, the control cirucit 30 supplies signals S_i and S_o to the voltage applying circuit 32 to vary the electrophoresis voltage V_a so as to prevent unwanted concentration of pigment particles 26 in the vicinity of the orifice 20. For example, the voltage V_a is varied in the following manner.

Referring to Fig. 5, normally a voltage V_1 is applied to the first electrode 18 as the electrophoresis voltage V_a, and, at steps 101 to 103 in the flow chart of Fig. 3, the length of time elapsed from the decay of a pulse P1 of the ejection voltage V_b applied to the electrode 22 is always checked and compared with the predetermined length of time T_1. If the length of time elapsed before applying a next pulse of the voltage V_b to the electrode 22 reaches T_1, the control circuit 30 supplies a voltage inversion signal S_i to the voltage applying circuit 32 to invert the polarity of the voltage V_a, at steps 104 and 105 in Fig. 3. Then a voltage $-V_3$ is applied to the electrode 18. The absolute value of $-V_3$ may or may not be equal to that of V_1. As the polarity of the electrophoresis voltage V_a is inverted, pigment particles 26 which have been migrating toward the orifice 20 and the particles 26 which have already concentrated in the vicinity of the orifice 20 migrate in the direction away from and opposite to the orifice 20.

If the ejection of the ink 24, viz. ejection of another agglomeration 28 of pigment particles 26, is not demanded before the lapse of another predetermined length of time T_2 from the inversion of the voltage V_a from V_1 to $-V_3$, the control circuit 30 outputs a voltage cutoff signal S_o which causes the circuit 32 to cut off the application of the voltage V_a (now $-V_3$) to the first electrode 18 (steps 106 to 108 in Fig. 3). Consequently the migration of pigment particles 26 in the ink chamber 16 is interrupted, and the print head 10 of the printer assumes a stand-by state while the pigment particles 26 are not concentrated in the vicinity of the orifice 20. If the ejection of ink is demanded before the lapse of T_2, the outputting of the signal S_i is stopped to change the volatge V_a from $-V_3$ to V_1 (steps 106, 107, 109), as shown in Fig. 6. Then the pigment particles 26 again migrate toward the orifice 20 and concentrate in the vicinity of the orifice 20. In that state, another pulse P2 of the ejection voltage V_b is applied to the electrode 22.

If the control circuit 30 receives a signal to cut off the power supply to the printer before the lapse of T_1 from the application of the pulse P1 in Fig. 5 to the electrode 22 (steps 102, 103, 110), the routine A shown in Fig. 4 is executed. At step 112, the control circuit 30 supplies the signal S_i to the circuit 32 to invert the polarity of the voltage V_a from V_1 to $-V_3$. So, the pigment particles 26 in the ink chamber 16 migrate in the direction away from and opposite to the orifice 20. At steps 113 and 114, after the lapse of the predetermined length of time T_2, the control circuit 30 supplies the signal S_o to the circuit 32 to cut off the application of the voltage V_a to the electrode 18. After that the power supply to the printer is cut off by a power supply control circuit (not shown). By this procedure, the concentration of pigment particles in the vicinity of the orifice 20 is maintained relatively low while the printer is in the inactive state. Therefore, the next operation of the printer does not suffer from clogging of the orifice 20 or unstable ejection of pigment particles.

Fig. 7 shows another embodiment of the invention. The printer of Fig. 7 is almost identical with the printer of Fig. 1, but in the print head in Fig. 7 the tip part 22a of the electrode 22 slightly protrudes from the ink chamber 16 through the orifice 20. That is, the tip 22b of the electrode 22 is outside of the ink chamber 16 and is close to the center of the orifice 20. In the control part 12 of the printer of Fig. 7, the control circuit 30 and the voltage applying circuit 32 are primarily for applying the electrophoresis voltage V_a to the electrode 18 and the ejection voltage V_b to the electrode 22. The control part 12 includes a waiting time checking circuit 32A, which finds the length of waiting time between the decay of a pulse of the ejection voltage V_b and the rise of a next pulse by using the print information S_c supplied from the computer 40. The length of waiting time refers to the length of time t_1 in Fig. 2. The circuit 34A supplies a signal S_t representing the length of waiting time to the control circuit 30. When the waiting time is not shorter than a predetermined length of time T_3, the control circuit 30 modifies the printing signal S_p to cause the circuit 32 to modify the ejection voltage V_b in a predetermined manner. The predetermined length of time T_3 may or may not differ from T_1 in Fig. 5.

The ejection voltage V_b in the form of a rectangular pulse is applied to the electrode 22 after concentrating the pigment particles 26 in the vicinity of the orifice 20 by the effect of the application of the electrophoresis voltage to the electrode 18. For surely and quickly ejecting an agglomeration 28 of pigment particles 26 by the pulse of the voltage V_b, it is desirable that a sufficiently large number of pigment particles 26 exist on or close to the surface of the tip part 22a of the electrode 22.

Referring to Fig. 8, as a result of concentration of pigment particles 26 in the vicinity of the orifice 20, a convex maniscus 24a of the ink 24 develops at the orifice 20. When the ejection voltage V_b is applied to the electrode 22 to produce an electric field directed toward the recording material 44, an electrostatic force causes further movement of the pigment particles 26 in the vicinity of the electrode 22 in the direction of the electric field. As a result the ink meniscus 24a augments to cover the protruding tip part 22a of the electrode 22, and the pigment particles 26 concentrate on the tip 22b

and the nearby surface of the electrode 22. Finally the pigment particles 26 in the vicinity of the electrode tip 22 are ejected toward the recording material 44 as an agglomeration 28 of a large number of particles 26 by overcoming the resistive force attributed to the surface tension and viscosity of the ink 24.

After the decay of the pulse of the voltage V_b the electrostatic force diminishes, and therefore the ink meniscus 24a gradually retrogrades by surface tension of the ink 24. By retrogradation of the meniscus 24a, pigment particles 26 are carried away from the tip 22b of the electrode 22. However, when the length of the waiting time (t_1 in Fig. 2) is relatively short, the retrogradation of the ink meniscus 24a is not serious so that the meniscus 24a quickly restores the form in Fig. 8 by the application of the next pulse of the voltage V_b to the electrode 22. Referring to Fig. 9, if t_1 is relatively long the retrogradation of the meniscus 24a proceeds to such an extent that pigment particles 26 scarcely exist on the tip 22b and the nearby surface of the electrode 22. Therefore, when the next pulse of the voltage V_b is applied to the electrode 22 it takes a relatively long time to move a large number of pigment particles 26 to the tip 22b of the electrode 22, and hence it is likely that the ejection of an agglomeration of pigment particles 26 is delayed or missed.

In the printer of Fig. 7 the ejection voltage V_b is modified, for example, in the manner as shown in Fig. 10 when the waiting time t_1 is not shorter than the predetermined length of time T_3. In Fig. 10 the waiting time t_1 between first and second pulses P1 and P2 is shorter than T_3, and t_1 between second and third pulses P2 and P3 is also shorter than T_3. So, the voltage V_b is not modified for the three pulses P1, P2 and P3. Between the third and fourth pulses P3 and P4, t_1 is not shorter than T_3. So, the voltage supplying circuit 32 under command of the control circuit 30 applies a pilot voltage V_p to the electrode 22 just before the application of the pulse P4 of the voltage V_b. The pilot voltage V_p is for moving pigment particles 26 existing in the vicinity of the orifice 20 toward the tip 22b of the electrode 22 without causing ejection of the particles 26. In this example, the pilot voltage V_p is a pulse train consisting of three rectangular pulses each of which has an amplitude of V_2 (the same as the amplitude of the pulses P1, P2, P3, P4) and a duration of t_3 which is shorter than the duration t_2 of the pulses P1, P2, P3, P4. By the effect of the pilot voltage V_p the pigment particles 26 are concentrated on the tip 22b and the nearby surface of the electrode 22. Therefore, when the pulse P4 of the ejection voltage V_b is applied to the electrode 22, the ejection of an agglomeration 28 of pigment particles is surely accomplished without delay.

It is possible to vary the amplitude (V_2) of the pulse P4 instead of applying the pilot voltage V_p to the electrode 22.

The above-described modification of the ejection voltage V_b can be made together with or indenpendently of the precedently described modification of the electrophoresis voltage V_a.

Claims

1. An ink-jet printer which uses an ink containing fine solid particles of a coloring material suspended in a carrier liquid, comprising:

   a print head comprising (i) on ink chamber to be filled with said ink, (ii) an ink ejection orifice located at one end of said ink chamber, (iii) a first electrode provided to said ink chamber to produce an electric field in said ink chamber such that by electrophoresis induced by said electric field said particles in said ink in said ink chamber are concentrated in the vicinity of said orifice, end (iv) a second electrode which is disposed in said ink chamber and has a tip part positioned close to said orifice to produce another electric field to eject at least one agglomeration of said particles together with a relatively small amount of said carrier liquid from said orifice; and

   control means comprising first means for applying a first DC voltage to said first electrode and periodically applying a second DC voltage in the form of pulse to said second electrode based on externally supplied print information, second means for checking the length of waiting time elapsed from the decay of a pulse of said second DC voltage and third means for modifying at least one of said first DC voltage and said second DC voltage when said waiting time is relatively long.

2. An ink-jet printer which uses an ink containing fine solid particles of a coloring material suspended in a carrier liquid, comprising:

   a print head comprising (i) an ink chamber to be filled with said ink, (ii) an ink ejection orifice located at one end of said ink chamber, (iii) a first electrode provided to said ink chamber to produce an electric field in said ink chamber such that by electrophoresis induced by said electric field said particles in said ink in said ink chamber are concentrated in the vicinity of said orifice, and (iv) a second electrode which is disposed in said ink chamber and has a tip part positioned close to said orifice to produce another electric field to eject at least one agglomeration of said particles together with a relatively small amount of said carrier liquid from said orifice; and

   control means comprising first means for applying a first DC voltage to said first electrode and periodically applying a second DC voltage in the form of pulse to said second electrode based on externally supplied print

information, second means for checking the length of waiting time elapsed from the decay of a pulse of said second DC voltage and third means for modifying said first DC voltage when said waiting time is not shorter than a predetermined length of time.

3. An ink-jet printer according to Claim 1 or 2, wherein said third means comprises means for inverting the polarity of said second DC voltage when the length of said waiting time reaches said predetermined length of time.

4. An ink-jet printer according to Claim 3, wherein said third means further comprises means for discontinuing the application of said first DC voltage to said first electrode after the lapse of another predetermined length of time from the inversion of said polarity.

5. An ink-jet printer according to Claim 4, wherein said third means further comprises means for returning the inverted polarity of said first DC voltage to the original polarity before the lapse of said another predetermined length of time from the inversion of said polarity if said print information implies applying a next pulse of said second DC voltage to said second electrode.

6. An ink-jet printer according to Claim 3, wherein said third means further comprises means for inverting the polarity of said first DC voltage while said waiting time is shorter than said predetermined length of time if said print information implies cutting off power supply to the printer.

7. An ink-jet printer according to Claim 6, wherein said third means further comprises means for discontinuing the application of said first DC voltage to said first electrode after the lapse of another predetermined length of time from the inversion of said polarity.

8. An ink-jet printer which uses an ink containing fine solid particles of a coloring material suspended in a carrier liquid, comprising:

a print head comprising (i) an ink chamber to be filled with said ink, (ii) an ink ejection orifice located at one end of said ink chamber, (iii) a first electrode provided to said ink chamber to produce an electric field in said ink chamber such that by electrophoresis induced by said electric field said particles in said ink in said ink chamber are concentrated in the vicinity of said orifice, and (iv) a second electrode which is disposed in said ink chamber and has a tip part positioned close to said orifice to produce another electric field to eject at least one agglomeration of said particles together with a relatively small amount of said carrier liquid from said orifice; and

control means comprising first means for applying a first DC voltage to said first electrode and periodically applying a second DC voltage in the form of pulse to said second electrode based on externally supplied print information, second means for checking the length of waiting time which is due to from the decay of a pulse of said second DC voltage before the rise of a next pulse of said second DC voltage and third means for modifying said second DC voltage when said waiting time is not shorter than a predetermined length of time.

9. An ink-jet printer according to Claim 8, wherein said third means comprises means for applying a pilot DC voltage to said second electrode before applying the next pulse of said second DC voltage to said second electrode if said waiting time is not shorter than said predetermined length of time, said pilot DC voltage being effective for moving the particles of the coloring material existing in the vicinity of said orifice toward the tip of said second electrode and ineffective for ejecting said particles from said orifice.

10. An ink-jet printer according to Claim 9, wherein said pilot DC voltage is a group of rectangular pulses each of which is shorter in pulse duration than each pulse of said second DC voltage.

11. An ink-jet printer according to Claim 8, 9, or 10, wherein said third means comprises means for augmenting the amplitude of said next pulse of said second DC voltage when said waiting time is not shorter than said predetermined length of time.

12. An ink-jet printer according to any one of Claims 1 to 11, wherein the tip of said second electrode slightly protrudes from said ink chamber through said orifice.

13. An ink-jet printer according to anyone of Claims 1 to 2, wherein said ink chamber becomes gradually narrower in cross-sectional area from an end opposite to said one end toward said one end.

FIG. 1

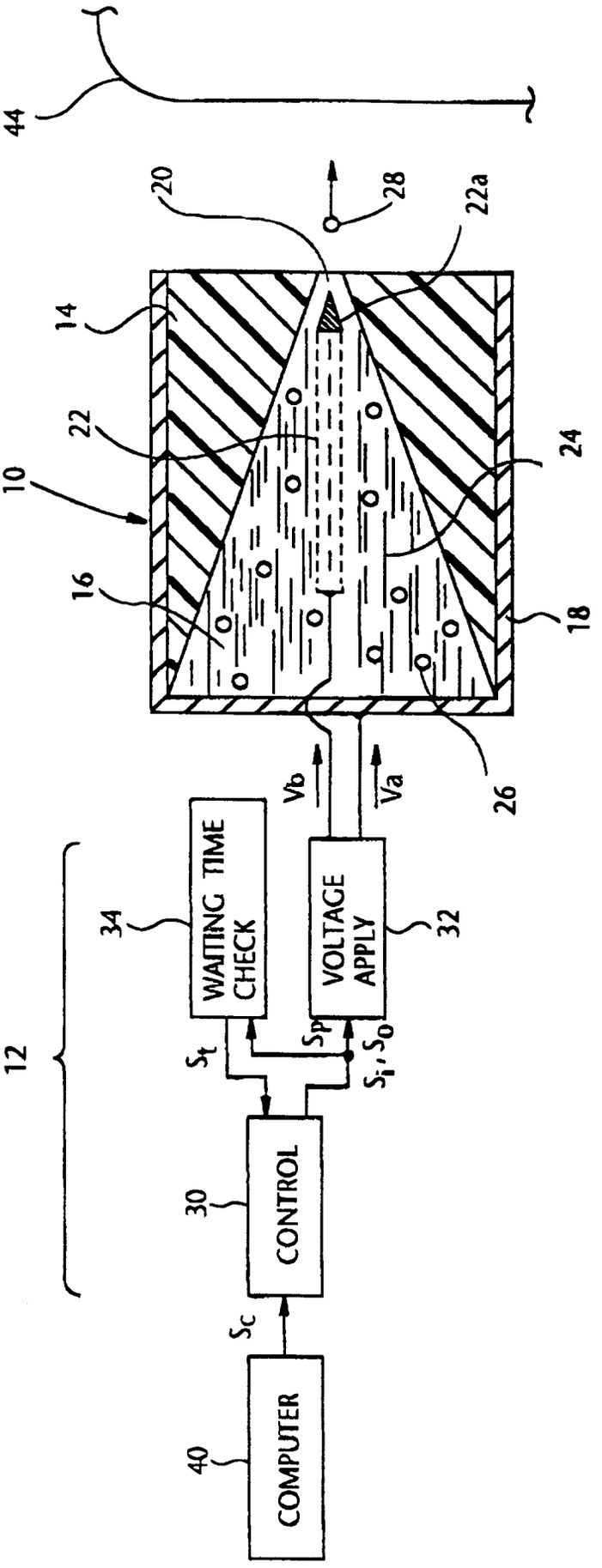
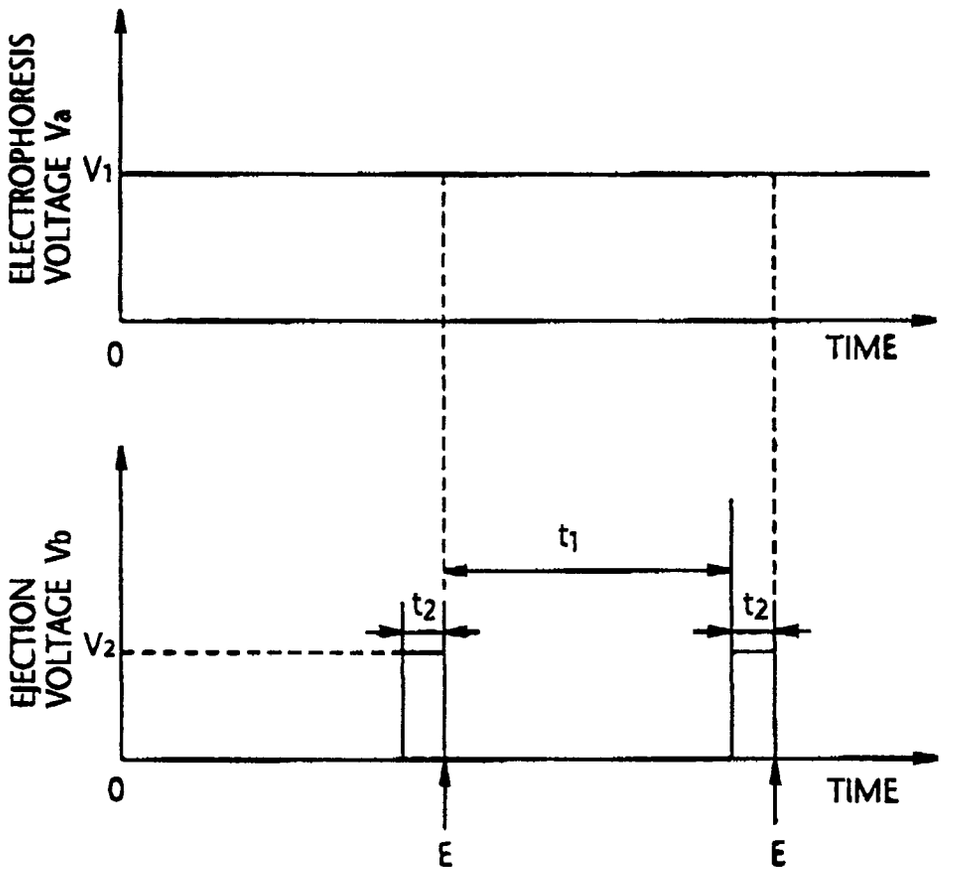

44
20
28
22a
14
22
24
10
16
18
26
Vb
Va
12
34
WAITING TIME CHECK
VOLTAGE APPLY
32
St
Sp
Si, So
30
CONTROL
Sc
40
COMPUTER

FIG. 2



E: EJECTION OF AN AGGLOMERATION OF PIGMENT PARTICLES

FIG. 3

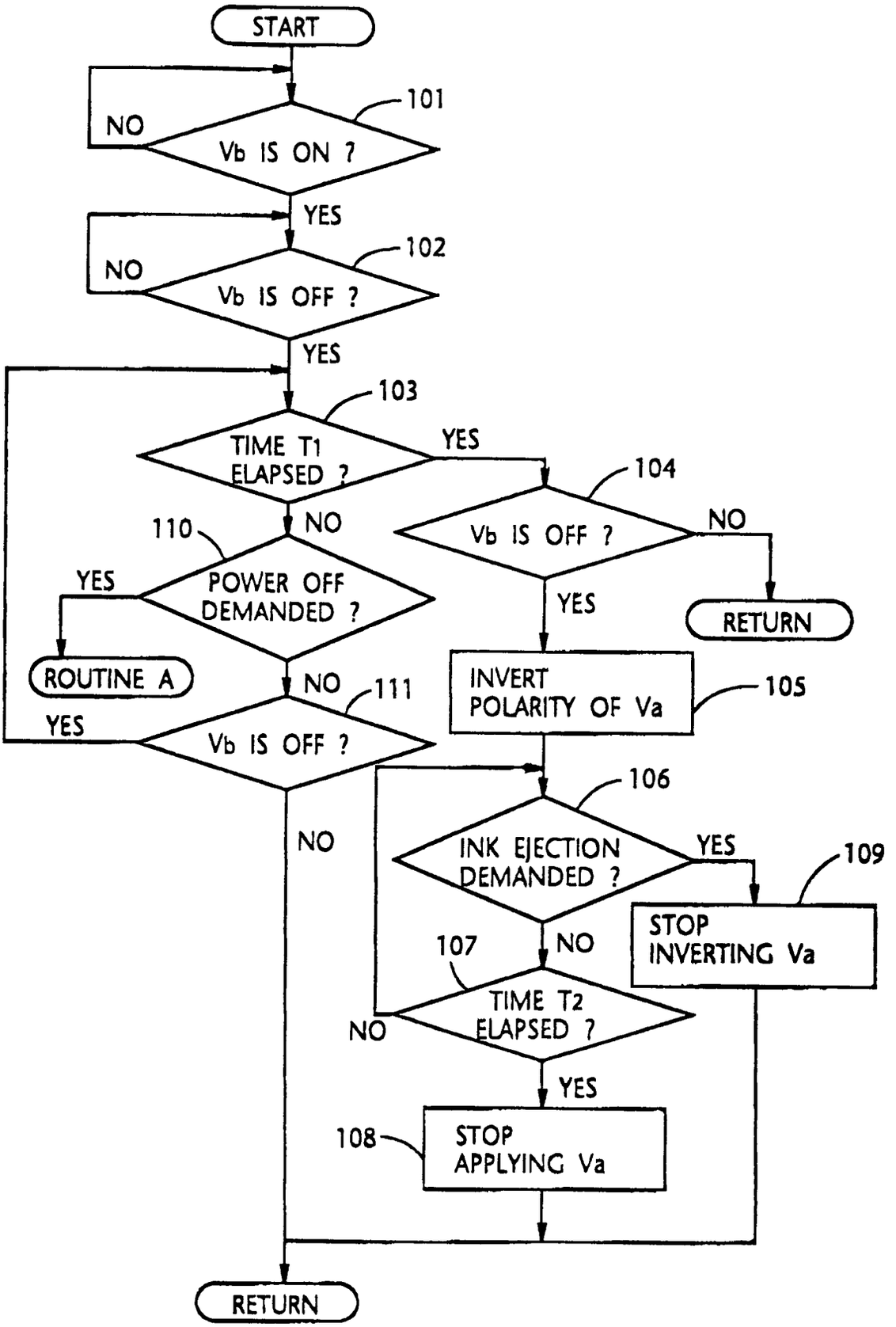
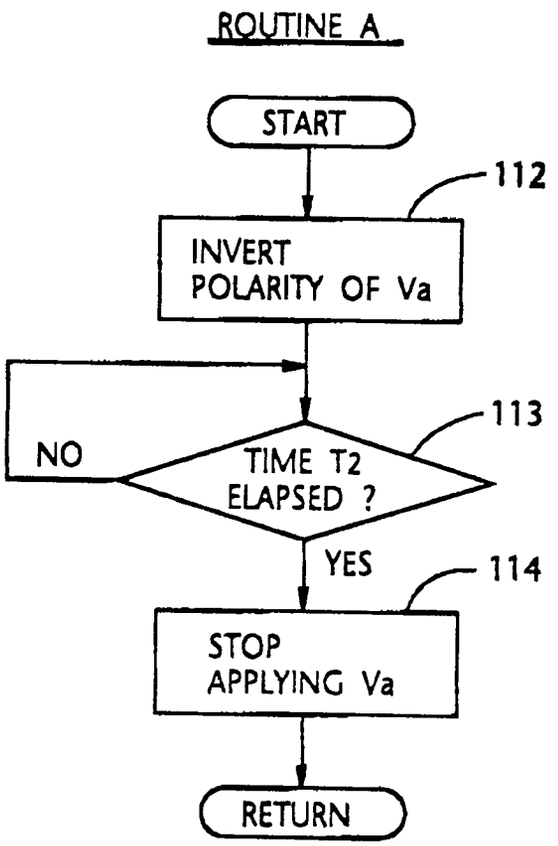

START
101
NO
Vb IS ON ?
YES
102
NO
Vb IS OFF ?
YES
103
TIME T1 ELAPSED ?
YES
104
Vb IS OFF ?
NO
RETURN
YES
INVERT POLARITY OF Va
105
NO
110
POWER OFF DEMANDED ?
YES
ROUTINE A
NO
111
Vb IS OFF ?
YES
NO
106
INK EJECTION DEMANDED ?
YES
109
STOP INVERTING Va
NO
107
TIME T2 ELAPSED ?
NO
YES
108
STOP APPLYING Va
RETURN

FIG. 4


ROUTINE A
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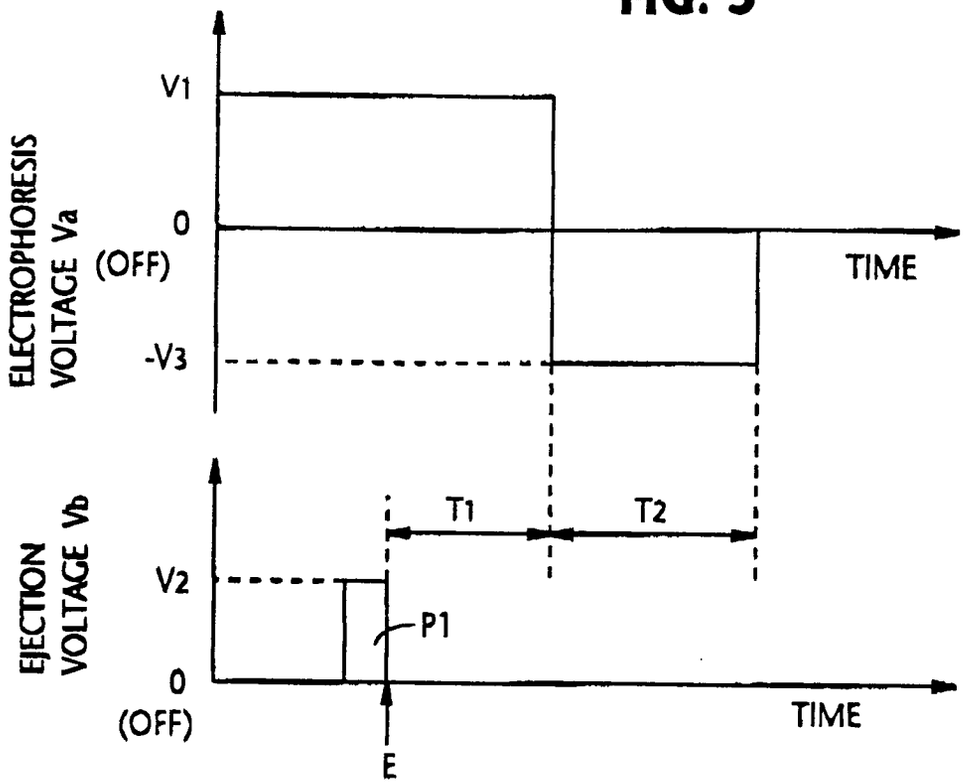
112
INVERT
POLARITY OF Va
113
NO
TIME T2
ELAPSED ?
YES
114
STOP
APPLYING Va
RETURN

FIG. 5



E : EJECTION OF AN AGGLOMERATION OF PIGMENT PARTICLES

FIG. 6

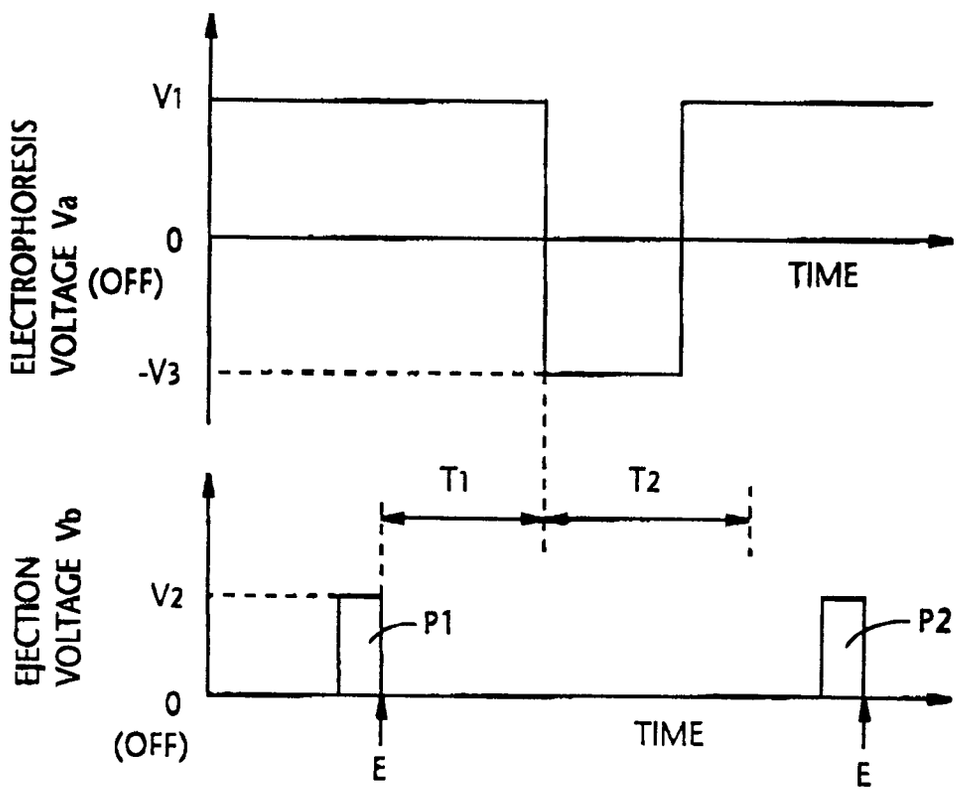


FIG. 7

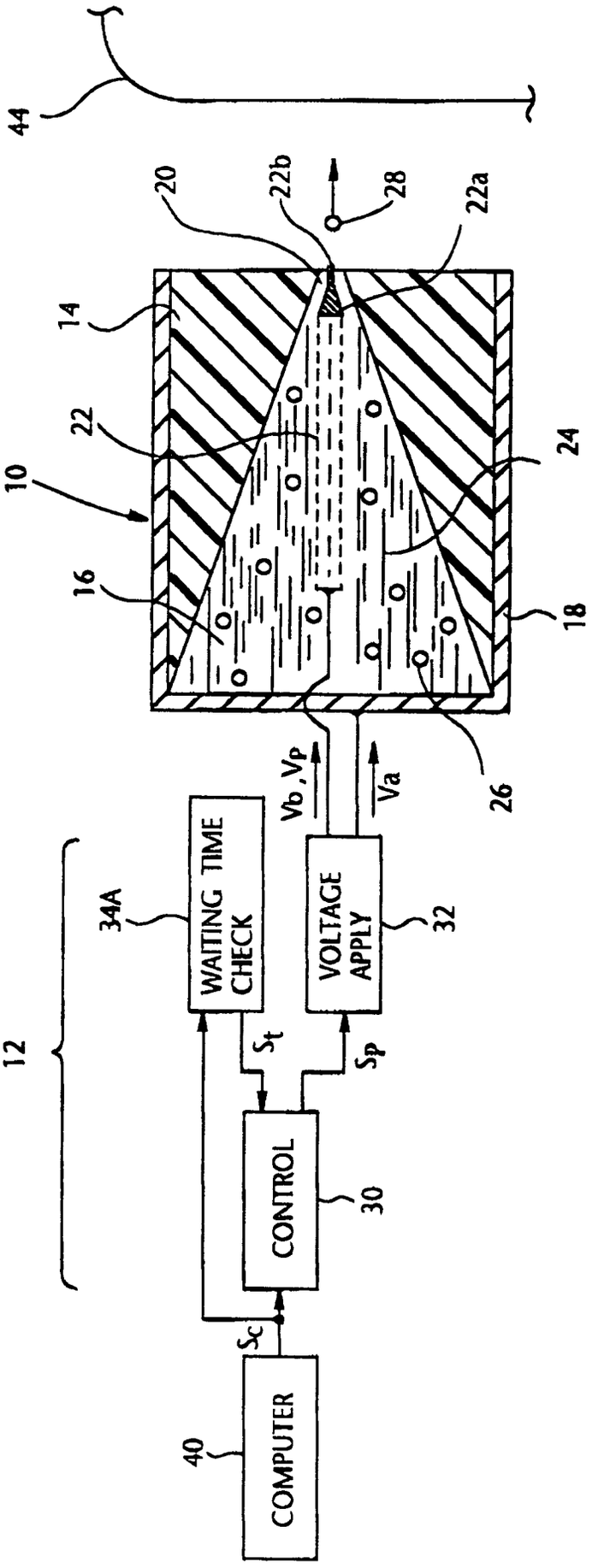

44
20
22b
28
22a
14
22
24
10
16
18
26
Vb, Vp
Va
34A
WAITING TIME CHECK
VOLTAGE APPLY
32
12
St
Sp
CONTROL
30
Sc
40
COMPUTER

FIG. 8

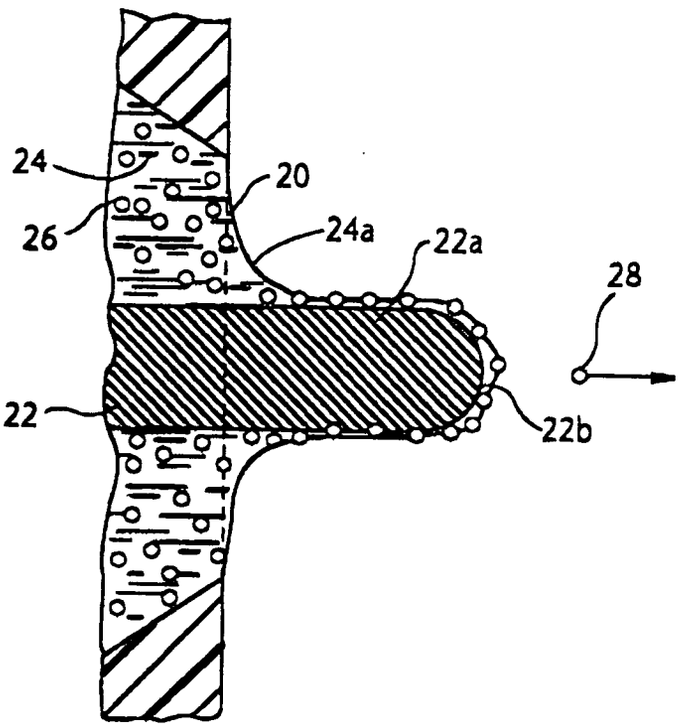


FIG. 9

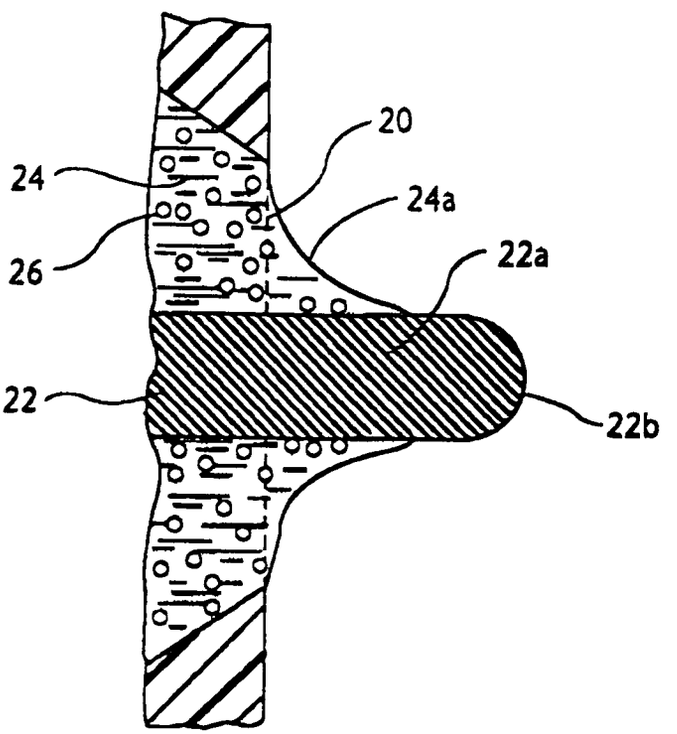
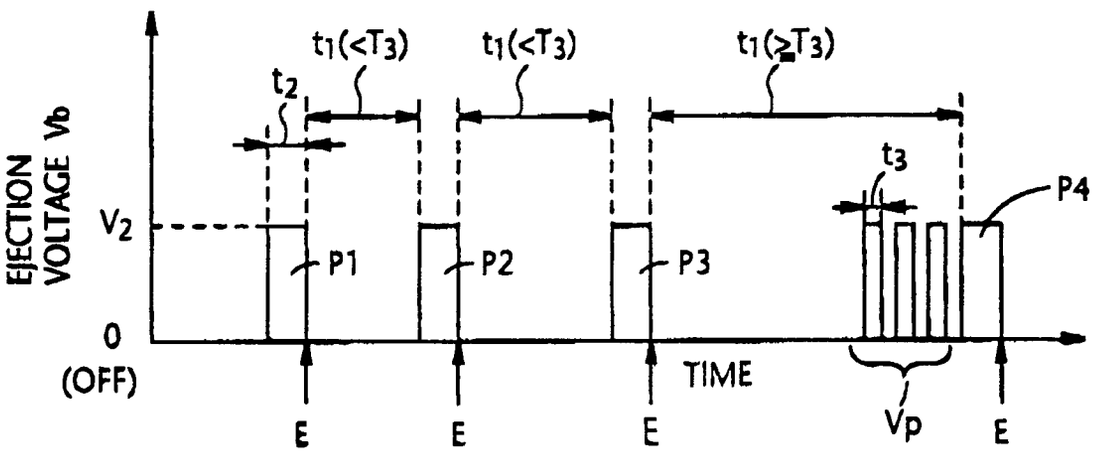


FIG. 10



E : EJECTION OF AN AGGLOMERATION OF PIGMENT PARTICLES